

## CONSERVING OCEAN BIODIVERSITY: TRENDS AND CHALLENGES

**Thomas F. Hourigan**  
**National Marine Fisheries Service, NOAA**

### Introduction

The ocean's biological diversity—its genetic resources, species, and ecosystems—provides immense benefits to the United States and to all of human society. Knowledge about these resources is still rudimentary; however, trends in the best studied species and ecosystems—commercially exploited fishes, protected marine mammals and turtles, and certain coastal ecosystems, such as coral reefs—indicate that these resources and their benefits are threatened by human activities both in the United States and globally. The U.S. government is already taking steps to address the threats, and actions are paying dividends in healthier resources. Recent initiatives, such as the President's Executive Order on Coral Reef Protection, signal a commitment to continue to improve the state of the marine environment. The key to further progress will depend on strengthening scientific research; applying a precautionary approach to resource use; strengthening partnerships with all stakeholders; and managing marine resources on an ecosystem basis. This paper highlights the ecosystem approach and the new Aquatic Restoration and Conservation (ARC) Partnership for Marine, Estuarine and Freshwater Living Resources as parts of a conceptual framework for organizing future actions to protect marine biodiversity.<sup>1</sup>

### The Living Ocean Treasure

The ocean's biological diversity—the living resources that compose it and the ecological processes that sustain it—forms a foundation for the quality of human life as well as the raw materials to enrich it. Biological diversity, or biodiversity, refers to the variety and variability among living organisms, and among the ecological complexes of which they are a part. Marine living resources provide essential economic, environmental, aesthetic, and cultural benefits to humanity. Sixteen percent of all animal protein consumed worldwide comes from the ocean. The United Nations Food and Agriculture Organization (FAO) estimates the total value to fishers of the

world's commercial marine catch at \$80 billion per year. The comparable value of fishes landed in the United States is \$3.5 billion, and commercial fisheries contribute \$21 billion to the U.S. economy. Besides food, marine living resources provide myriad products including fertilizers, animal feed, medi-

cines, and aquarium fishes.

*The ocean's biological diversity—the living resources that compose it and the ecological processes that sustain it—forms a foundation for the quality of human life as well as the raw materials to enrich it.*

The value of marine biodiversity extends far beyond fisheries and other products. Marine ecosystems also provide natural goods and services such as carbon storage, atmospheric gas regulation, nutrient cycling, and waste treatment.

Coral reefs, man-

groves, and kelp forests protect coastal areas from storm damage. Marine algae contribute nearly 40 percent of global photosynthesis. The values of these marine ecosystem services greatly exceed direct use values, yet they generally are not incorporated into economic or policy calculations. Globally, the value of marine ecosystem services has been estimated at \$8.4 trillion per annum for open ocean ecosystems, and \$12.6 trillion for coastal ecosystems (Costanza et al. 1997). These services depend on marine biodiversity, even though the processes that underlie this dependence are still unclear.

As human populations increase, demands have accelerated for food, products, and services from the ocean, as well as for living and recreational space on its shores. The primary threats to marine biodiversity are fisheries operations (both direct overfishing and indirect fishing impacts—e.g., bycatch of non-target and protected species, habitat destruction by trawls and other gear or techniques, and other ecosystem effects that may accompany fishing activities), chemical pollution and eutrophication, physical alteration of coastal and marine habitats, invasions of exotic species, and ultraviolet-B radiation damage to phytoplankton and zooplankton resulting from stratospheric ozone depletion (NRC

1995). Looming on the horizon is the threat of human-caused climate change with potentially major negative effects on tourism, freshwater supplies, fisheries, and biodiversity. These factors also have been identified by the Parties to the Convention on Biological Diversity<sup>2</sup> as key threats (UNEP/CBD 1995).

### ***Trends in the Health of Marine Biodiversity***

Knowledge about marine species and ecosystems lags far behind that of terrestrial systems. We cannot even characterize the health of many common marine species and ecosystems. What relatively little is known about the state and trends of living marine resources is based on species exploited commercially for fisheries; protected marine mammals, turtles, and fishes; and certain commercially significant and accessible coastal ecosystems such as wetlands and coral reefs. Until recently, the oceans were thought to be a limitless source of food and natural resources, and a limitless sink for human pollution. Trends for these resources during the last few decades, however,

have shown that human activities are reaching and often exceeding the productive limits and recuperative potential of the ocean.

#### **A. Fisheries**

Many commercial fish stocks reveal a pattern of declining populations. Recent trends indicate that about one-third of the resources on which fishers depend are overfished in the United States and worldwide (Fig. 1). Without major changes in fishery management, FAO estimates that global landings will not be able to exceed current levels despite increased demand from growing populations, and could be reduced by as much as 25 percent (FAO 1996a). Despite the collapse of certain fisheries, U.S. management actions have contributed to several successes, including Alaska groundfish, king and Spanish mackerel, striped bass, and surf and ocean quahogs.

Beyond the impacts of overfishing, fishery operations also have tremendous impacts on marine ecosys-

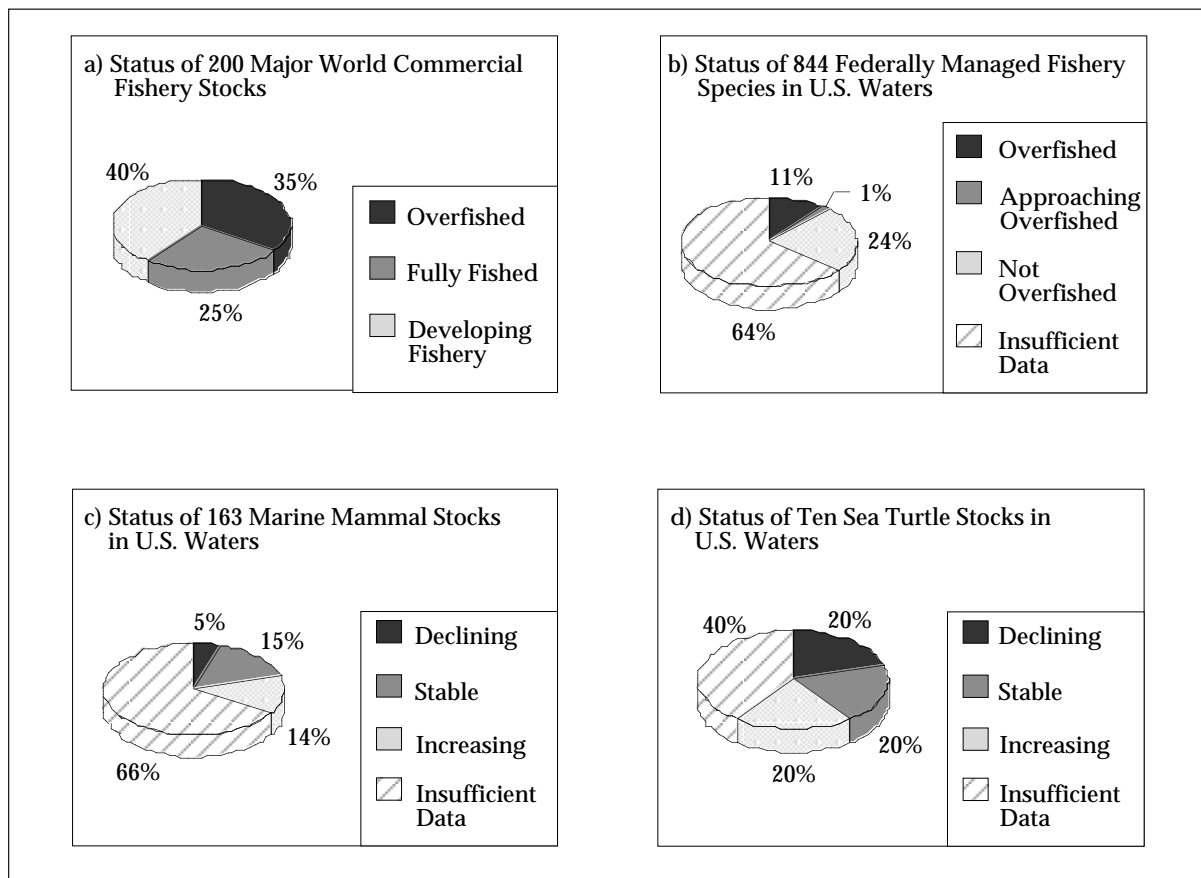


Figure 1. Status of selected marine living resources. a) World fisheries (FAO 1996a); b) U.S. Federally managed fisheries (NMFS 1998); c) & d) Marine mammals and sea turtles (NMFS 1996).

tems. Globally, about 60 billion pounds of sea life are destroyed as discarded bycatch each year (FAO 1996b). Additionally, it has recently been estimated that bottom trawls and similar fishing gear scrape 14.8 million square kilometers of sea bottom annually, an area equivalent to over half the world's continental shelves (Watling and Elliot, 1998). Although the impact of this destruction on biodiversity and productivity is unknown, its magnitude must give us pause.

*Recent trends indicate that about one-third of the resources on which fishers depend are overfished in the United States and worldwide.*

## B. Protected Marine Species

Protected marine species in the United States include marine mammals and species listed under the Endangered Species Act (ESA). In the past, the exploitation or incidental capture of marine species, along with a lack of adequate natural resource management policies, led to the decline and even extinction of many species. Protection under the ESA, Marine Mammal Protection Act, and the International Whaling Commission has led to increasing populations of certain marine mammals (e.g., gray whales) and at least two sea turtle species in U.S. waters. Still, habitat destruction and human activities continue to place other species in jeopardy. For example, 23 salmonid populations have been listed or proposed for listing as endangered or threatened since 1991, while populations of the northern right whale and Hawaiian monk seal continue to decline. Meanwhile, less well-studied marine organisms are being lost before ever being identified, much less protected.

## C. Key Ecosystems - the Coral Reef Example

As the world's most biologically diverse marine ecosystems, coral reefs are home to one-third of all marine fish species and tens of thousands of other species. Coral reef areas under U.S. jurisdiction cover approximately 16,879 square kilometers (NOAA 1998b). Despite their importance, shallow water coral health and cover have declined worldwide over the last two decades. It is estimated that 58 percent of the earth's coral reefs are at high or moderate risk from overexploitation, coastal development, and pollution (Bryant et al. 1998). In the United States, coral reefs appear threatened wherever

they are close to large concentrations of people; however, data are available to evaluate the status and trends of U.S. coral reefs in only a few sites (NOAA 1998b). The International Year of the Reef, 1997, and President Clinton's 1998 Executive Order on Coral Reef Protection are providing impetus to new reef monitoring programs that should greatly increase our understanding of the status and outlook for coral reefs worldwide.

### ***A Challenge for the Future: The Ecosystem Approach to Conserving Marine Biodiversity***

The U.S. government, in partnership with public and private stakeholders at home and internationally, is taking action to address the threats to living marine resources and to ensure the promise of these resources for future generations. Hourigan et al. (1998) outlined five critical elements at the heart of this new strategic vision:

1. Investing in science in the interest of stewardship. Basic assessment and monitoring of the status and trends of resources, as well as economic and social information, are the fundamental tools of natural resource managers.
2. Applying the precautionary approach. Even the best science cannot ensure adequate management, since marine systems are characterized by a great deal of natural variability. The precautionary approach states that in the face of uncertainty, managers and decision makers must err on the side of conservation of living marine resources and protection of the environment. The precautionary approach has been conceptually best developed in the fishery sector (e.g., the FAO Code of Conduct for Responsible Fisheries and the United Nations Straddling Stocks Agreement) and is being integrated into U.S. fishery policy and practice. The challenge will be to implement the precautionary approach in fisheries and to broaden its application to other arenas of ocean resource management.
3. Applying new technologies to ensure the environmental sustainability of marine aquaculture. World population is expected to increase by one billion people during the next decade, yet future seafood harvests from the wild are not expected to increase. As humans once moved from hunting to agriculture on land, they must soon move from reliance on wild fish stocks to marine aquaculture in the oceans. The success of this move depends upon employing new

technologies to address the environmental problems that have plagued aquaculture in the past.

4. Building Partnerships. Successful management of ocean living resources is often less a question of science and technology than one of human behavior and balancing legitimate short- and long-term social needs and aspirations. U.S. federal programs and policies are reaching out to involve stakeholders in decision-making and implementation.

5. Exploiting the full potential of an ecosystem-based approach to resource management. Each individual organism has a habitat, which it needs to live and reproduce, and depends on a community of other species for food and survival. This interconnected community of living things, including humans—their dynamic interactions with each other and the physical environment, and their overlapping mosaic of habitats—together constitute an ecosystem.

Increasingly, the United States is adopting an ecosystem approach to management designed to sustain or restore natural systems and their functions and values (Interagency Ecosystem Management Task Force 1995). The ecosystem approach has also become a major touchstone advocated by the Convention on Biological Diversity for the conservation and sustainable use of marine biodiversity (UNEP/CBD 1995). An ecosystem approach to management is applied within a geographic framework defined primarily by ecological boundaries. The ecological boundaries of ocean ecosystems and the services they provide reach across traditional state and international boundaries, and they are linked to water and soil systems in watersheds and to each other through ocean currents. Thus, effective management will require expanding both interstate and international cooperation.

Applying this ecosystem approach represents the greatest challenge of the coming decades. Current management still generally deals with fish or endangered species as isolated stocks, and with threats as individual rather than cumulative insults to ocean systems. The ecosystem approach requires integrating the current patchwork of management tools that address endangered species, fisheries, pollution, watersheds, and coastal zones into a coherent whole. Federal and state integrated coastal zone management programs and watershed management plans

that address non-point source pollution are important pieces of the puzzle. So also are the new “Essential Fish Habitat” provisions of the 1996 Sustainable Fisheries Act and increasing use of habitat conservation agreements with states, tribes, and private land owners to address endangered species management. To date, however, these have not been placed in a context that recognizes the scale and interconnectedness of ocean living systems.

Marine and coastal protected areas in the National Marine Sanctuary Program, the National Estuarine Research Reserve System, the National Estuary Program, and other national and state parks can

provide important refuges for marine biodiversity. However, these areas currently provide only limited protection from fishing impacts. Twenty-two percent of U.S. federal lands are “no-take” wilderness areas. In contrast, the federal government has jurisdiction over marine areas eight times larger than the

*As the world's most biologically diverse marine ecosystems, coral reefs are home to one-third of all marine fish species and tens of thousands of other species.*

federal land areas, but only 0.002% of these are currently “no-take” marine wilderness areas (Brailovskaya, 1998).

Management of terrestrial systems has been revolutionized by the application of watershed management and coastal zone management approaches. The challenge over the next century will be to expand these zoning approaches to the nearshore waters and beyond. We must:

1. Identify areas of important biological diversity and productivity, habitats for endangered species and commercial and recreational fisheries species, and coastal and marine areas that provide key ecosystem functions;
2. Map sources of pollution and other human impacts on these areas; and
3. Conserve representative productive and pristine areas and restore priority habitats that are degraded.

The National Oceanic and Atmospheric Administration has recently formed a partnership with the U.S. Geological Survey and other federal agencies, states, NGOs, and professional organizations to take the

first analytical steps in this direction on a nationwide basis. We have begun the Aquatic Restoration and Conservation (ARC) Partnership for Marine, Estuarine and Freshwater Living Resources. The goal of the ARC Partnership is to ensure the conservation of our nation's freshwater, estuarine and marine living resources by creating a common information base and options for preserving the ecological and economic integrity of these resources into the 21st Century.

ARC builds on the successful Terrestrial Gap Analysis Program. Gap analysis is a science-based program for identifying the degree to which native animal species and natural communities are represented in our present-day mix of conservation areas. Those species and communities not adequately represented in the existing network of conservation areas constitute conservation "gaps." The Gap Analysis Program provides broad geographic information on the status of species and their terrestrial habitats in order to provide managers, planners, and policy makers with the information they need to make better-informed decisions.

Making full use of new approaches—analytic tools such as ARC and management tools such as fishery "no-take" zones that protect fishes, their habitat, and biodiversity—will allow management on scales that are meaningful to ocean living resources. They can then be placed in watershed and integrated marine and coastal area management regimes that involve all stakeholders. Together, these offer the promise of better conserving marine biodiversity, our ocean's living treasure.

### **Literature Cited**

- Brailovskaya, T. 1998. Obstacles to protecting marine biodiversity through marine wilderness preservation: Examples from the New England region. *Conservation Biology* 12:1236-1240.
- Bryant, D., Burke, L., McManus, J., and Spaulding, M. 1998. *Reefs at Risk: A map-based indicator of threats to the world's coral reefs*. World Resources Institute Report. 56 pp.
- Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P., and van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253-260.
- Food and Agriculture Organization (FAO) (United Nations). 1996a. *State of the World Fishery and Aquaculture*. FAO Fisheries Circular. FAO.
- FAO 1996b. *Report of the technical consultations on reduction of wastage in fisheries*. FAO Fisheries Report 547. Tokyo, Japan.
- Hourigan, T.F., Milazzo, M., Kiraly, S.J. and Osborn, K.W. 1998. *Ensuring the Sustainability of Ocean Living Resources*. Proceedings of the Ocean Community Conference '98. pp. 651-655.
- Interagency Ecosystem Management Task Force. 1995. *The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies, Volume I*. National Technical Information Service. U.S. Dept. of Commerce. 55pp.
- National Marine Fisheries Service (NMFS). 1996. *Our Living Oceans: Report on the Status of U.S. Living Marine Resources, 1995*. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-19, 160 pp.
- NMFS. September 1997. *Report to Congress on the Status of Fisheries in the United States*.
- National Oceanic and Atmospheric Administration (NOAA). 1998a. *Year of the Ocean Discussion Papers*. NOAA.
- NOAA. 1998b (on-line). The extent and condition of U.S. coral reefs by S.L. Miller and M.P. Crosby. *NOAA's State of the Coast Report*. Silver Spring, MD: NOAA. <http://state-of-coast.noaa.gov>
- National Research Council. 1995. *Understanding Marine Biodiversity: A Research Agenda for the Nation*. National Academy Press; Washington D.C. 114 pp.
- United Nations Environment Programme (UNEP)/CBD. 1995. *The Jakarta Mandate on Marine and Coastal Biological Diversity: Decisions of the Second Meeting of the Conference of the Parties to the Convention on Biological Diversity*. Jakarta, Indonesia, November 6-17, 1995. .UNEP.
- Watling, L. and E.A. Norse. 1998. Disturbance of the seabed by mobile fishing gear: A comparison to forest clearcutting. *Conservation Biology* 12:1180-1197.

**Notes**

1 The trends in marine living resources described in this paper draw on the recent review developed for the *Year of the Ocean Discussion Papers* (NOAA 1998a; and Hourigan et al. 1998). The conclusions derived from these trends, and suggested options for future action, are the author's and do not necessarily reflect the policies of the U.S. Government.

2 The United States has signed, but not yet ratified, the Convention on Biological Diversity.